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Does kin-selection theory help to explain support networks among farmers in South-Central Ethiopia?

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Abstract

Social support networks play a key role in human livelihood security, especially in vulnerable communities. Here we explore how evolutionary ideas of kin selection and intra-household resource competition can explain individual variation in daily-support network size and composition in a South-Central Ethiopian agricultural community. We consider both domestic and agricultural help across two generations with different large-wealth transfer norms that yield different contexts for sibling competition.

For farmers who inherited land rights from family, first-borns were more likely to report daily support from parents and to have larger non-parental kin networks (n=180). Compared with other farmers, first-borns were also more likely to reciprocate their parents' support, and to help non-parental kin without reciprocity.

For farmers who received land rights from the government (n=151), middle-born farmers reported more non-parental kin in their support networks compared with other farmers; non-reciprocal interactions were particularly common in both directions. This suggests a diversification of adult support networks to non-parental kin, possibly in response to a long-term parental investment disadvantage of being middle-born sons. In all instances regardless of inheritance, last-born farmers were the most disadvantaged in terms of kin support.

Overall, we found that non-reciprocal interactions among farmers followed kin selection predictions. Direct reciprocity explained a substantial part of the support received from kin, suggesting the importance of the combined effects of kin selection and reciprocity for investment from kin.

Introduction

Social capital, alongside natural capital, physical or produced capital, and human capital, is an important part of sustainable development. Because social capital can be defined as "the features of social organization, such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" (Putnam 2000), social capital, by virtue of its collective nature, has an important influence on resource sustainability at a population/community level (Pretty 2003). In developing countries that lack resource access, infrastructure, or social policies to support vulnerable communities, networks have been shown to not only provide the social insurance and safety nets that foster resilience and recovery in times of hardship (Fafchamps and Lund 2003, Caudell, Rotolo and Grima 2015), but also to build human capital, material capital, and improve community well-being (Narayan and Pritchett 1999, Aldrich 2012, Aldrich and Meyer 2014).

Using an evolutionary perspective, this research aims to investigate daily support networks as strategies used by individuals and families in rural South-Central rural Ethiopia and to identify the most vulnerable among them. This agricultural population is largely dependant of land for cereals and vegetables production. Personal support networks are comprised of kin and non-kin supporters, which is an important distinction from an evolutionary perspective: kin-selection theory predicts that kin will allocate resources to their relatives in a manner that enhances transmission of their common genes (Hamilton 1964). In other words, kin support is an investment in one's own fitness, either directly (via direct descendants) or indirectly (in other kin), where fitness is defined as the survival of the biological lineage across generations, or the number and quality of descendants achieved by accumulation of social, material, and biological capital. According to kin selection, individuals face trade-offs in their effort to acquire finite resources; thus, they make decisions (consciously or not) about resource allocation in their support networks according to genetic relatedness (Hamilton 1964). Recipient characteristics other than genetic relatedness also influence resource allocation decisions, such as reproductive potential and survival rate, which are shaped by gender (Trivers 1972, Trivers and Willard 1973) and birth order (Clutton-Brock 1984; Hrdy and Judge 1993). In theory, any individual characteristics influencing reproductive potential and survival rate

might possibly influence kin investment decision. In rural Ethiopia, land access influences livelihood security and reproduction and is, thus, probably important to kin investment patterns.

Parental investment, which is the most fundamental kin investment, significantly influences the fitness of parents and children (Trivers 1974); it includes various investments, from parental care and education (Gibson and Sear 2010, Gibson and Lawson 2011), to wealth transfers during life and at death (Judge and Hrdy 1992, Hrdy and Judge 1993, Gibson and Gurmu 2011). Among the various land owner societies facing limited resources around the world, a gradient of wealth transfer systems has evolved from biased multigeniture (Clarke and Low 1992, Towner 2001, Faurie, Russel and Lumma, 2009, Gibson and Gurmu 2011) to unigeniture (Boone 1986, Hrdy and Judge 1993, Voland and Dunbar 1995, Strassman and Clarke 1998), favouring some children over others, possibly to ensure lineage survival across generations and/or to avoid capital fragmentation and economic decline within very few generations. As a consequence, favoured children enjoy a better resource status and, possibly, might enjoy larger kin support because they represent safer investment for the future of the lineage compared with their sibling.

Research on parental investment, has yielded variable and occasionnally conflicting results about birth order (Draper and Hames 2000, Faurie, Russel and Lumma, 2009, Stanton et al. 2014). In Ethiopia, a first-born son advantage for agricultural productivity, marriage, and reproductive success has been shown in the context of family land transfers but was not observed when no family land transfers occured (Gibson and Gurmu 2011), suggesting that inequalities in intra-household material resource access for brothers only arise in the context of competition for limited resources.

The importance of kin selection and reciprocity for cooperation with kin is discussed in the literature (Clutton-Brock 2009, Jaeggi and Gurven 2013, Taborsky 2013, Carter and Wilkinson 2013). Some individuals might actively engage in network manipulation by seeking extra interactants to secure additional support; one way to lower the cost for potential interactants is through reciprocity, which lowers the costs for interactants (Trivers 1971).

Herein, we investigate whether patterns in the kin and non-kin make-up of adult children's support networks, reinforces or offsets patterns of material resource access for two generations of Ethiopian

agriculturalists with different large-wealth transfer patterns.

The Ethiopian context offers a unique setting to look directly at the effects of intra-household competition and kin investment. Ethiopia's recent political past, including the Marxist revolution that led to land confiscation and subsequent redistributions in 1975, 1988, and 1990 in this agricultural area, provides a natural experiment to study two cohorts of farmers that received land either from family transfer (inheritor group) or from government (redistribution group). In the study community, family land transfers primarily concern male farmers. Even the successive government redistributions targeted male heads of household. Nowadays, by law, all children, females and males, have the right to claim their share of inheritance. In practice, most families provide land to their sons and provide other type of goods to their daughters, who marry out their communities. Because of rapid population growth and limited land availability, farmland is becoming a scarce resource in this part of Ethiopia, so we expect this to increase the investment biases predicted by kin selection, but in different ways for the two farmer groups.

Farmers in the younger group became adults after the government redistribution programs ended; thus, their land access was completely determined by their parents, they received farmland before or for their marriage and received or might receive additional land upon their parents' deaths. Previous research suggests a multigeniture with a first-born son advantage for the youngest generation (Gibson and Gurmu 2011).

The oldest group's parents were not permitted to favour any of their sons for large wealth transfers because, in theory, all sons received land of equal size and quality from the government; furthermore, this sweeping policy likely affected other types of parental and kin investment besides wealth transfers. Studies on parental investment in the context of equal resource access suggest that first and last-born children tend to be advantaged over middle-born children (Hertwig, Davis and Sulloway 2002), who receive fewer cumulative investment due to competition with younger and older siblings. Faurie, Russel and Lumma (2009) corroborated Hertwig, Davis and Sulloway's (2002) finding among sons of rural pre-industrial Finns: middle-born sons appeared to produce significantly less offspring than first- or lastborn sons. Concerning relational capital biases, cues from studies of Western societies suggested that disadvantaged children might offset their parental-investment disadvantage by manipulating their networks through

diversification of support including other kin (Salmon and Daly 1998, Rhode et al. 2003,) or non-kin (Salmon and Daly 1998, Salmon 2003).

Thus, to understand the complexity of support patterns, it is important to discriminate among sources of support (e.g., parents, non-parental kin, and non-kin), to identify the directions of support interactions (non-reciprocal or reciprocal), and to discriminate between birth order and intra-sex birth order. Finally, the daily agricultural and domestic support networks of household heads should be an accurate proxy for measuring social capital in a mixed economy where cash is not widespread, because such support entails meaningful energetic and material costs and has direct impacts on household wellbeing. Because this study population is patriarchal, patrilineal, and patrilocal, with strong gender differences in socio-economic activities that could affect individuals' social networks, we focused on the support networks of male heads of household.

This paper aims to test two sets of evolutionary predictions about daily support network size and composition among Ethiopian farmers: 1) Daily support networks will vary according to sibling competition, with different birth-order biases for the generation groups. 2) Farmers' daily support networks will pattern in a way that is consistent with reciprocity and kin-selection theory.

Prediction 1: We will observe birth-order biases in support network size and composition

At the outset, we expect to observe two scenarios regarding daily subsistence and domestic support:

1. In the context of limited resources, first-born sons might interact more with parents and with non-parental kin compared with other birth-order categories, because, first-born sons represent a less risky investment for lineage survival (Hrdy and Judge 1993, Gibson and Gurmu 2011). Later-born sons being disadvantaged in kin interactants, might diversify their networks to include non-kin, possibly through reciprocity
2. For farmers who received their land from the government without discrimination, first and last-born sons might have enjoyed extra-parental investment in terms of cumulative investment in their lifetimes (Kidwell 1982, Sulloway 1996, Hertwig, Davis and Sulloway 2002, Faurie, Russel and Lumma 2009). If those differences held into adulthood, middle-born sons might still represent worthwhile investment for non-parental kin, especially if they are more active in diversifying their networks. They may do this by diminishing the costs of investment for the givers through

reciprocity (Trivers 1971, Salmon 2003). This strategy would result in middle-born sons having larger non-parental kin and non-kin networks compared with first and last-born sons.

Prediction 2: Variation in farmers' support networks is consistent with reciprocity and kin-selection theories

Reciprocity is a strategy by which people obtain greater resource security and social support by diversifying their networks and engaging in interactions with more people. However, because of time and cognitive constraints (Dunbar 2008) that limit the number of social contacts a person can meaningfully manage, the benefits of a reciprocal support strategy are limited. We expect that most non-kin interactions would be based on reciprocity, while non-direct reciprocity (unidirectional interactions) would be more common with kin and even more common with close-kin, according to expected benefits of inclusive fitness (Hamilton 1964; Trivers 1972). Kin might constitute an important proportion of men's reciprocated social ties, because kin interactants can benefit from both inclusive fitness and reciprocity.

Methodology

Participants and study sites

Data were collected from two representative neighbouring villages with high out-migration, during 2009 and 2010. The communities were selected from a pool of villages previously studied by Gibson (2002) in the Oromia region, Ethiopia, in the green midlands (altitude of 2200 to 2700m) between the town of Iteya and the city of Assala, where the socio-economics and demographic context is well known. The study communities had no electricity access, no direct road access and no working tap-water access at the time of the data collection. Community members relied mostly on a mixed economy, where cash was sporadically available. The altitude and the relatively temperate climate permits growth of a variety of cereals (wheat, teff, barley, sorghum, maize), vegetables (cabbages, carrots, potatoes, lentils, onions etc) and smaller quantities of other crop types (tobacco, oil seeds, eucalyptus) on their small farmland plot (landsize of 5ha maximum). Farmers cultivate their land with animal-drawn plows. Remittances from out-migration were rare (Gibson and Gurmu 2012) despite a relative proximity to urban centres (~10−15km). The ethnic composition of the study population includes Shoa Oromo, Arsi Oromo, and Amara. Shoa and Amara families have been intermarrying for several generations and are Christians, while Arsi Oromo are Muslims and do not usually intermarry with non-Muslims. Our sample included mostly Oromo farmers and a small number of Amara farmers (20.5% of the redistribution group and 20.6% of the inheritor group) that did not allow for more detailed analyses. Traditionally, Oromo and Amara have different inheritance systems. Contrary to most of Oromo women, Amara women had access to family land. However, governmental redistribution focused on the head of household, resulting in women being excluded from redistribution and land access. Amara women from the youngest generation are more likely to receive land from their family compared with Oromo women. However, a study on land access for an Amara population has shown a first-born son advantage for inheritance (Congdon Fors, Houngbedji, Lindskog 2017), suggesting similar patterns of parental bias for Oromo and Amara for the young generation. All families arrived between the 19th century and the last Italian war (1935), and have known a system of small landlords, tenants, small landholders and landless workers. The Marxist Derg regime came to power in 1974 and started an agrarian reform in 1975. In 1975, land lordism, tenancies, inheritances were abolished, and all lands came under government control. The peasant associations (PAs), which are the lowest local administrative units,

controlled land access. PAs confiscated and redistributed periodically lands, in 1975, 1988, and 1990 to households based on family size, land availability and land quality (Tefera et al. 2002). Today, a vast majority of farmers in the study sites are still members of the PAs, and take part in meetings about local development and agriculture. Informal contractual tenure arrangements were not resported as widespread in those villages by the farmers, but might be underestimated due to their unofficial status (−up to 24% of all farmlands in the same area might be under contract, Gavian and Ehui 1999). It is also not known to what extent contracts are made within the family, and are, thus, not reported. Focus group discussions have revealed numerous family strategies for land sharing among sons, including brothers sharecropping a piece of land provided by their father, fathers passing on officially the land rights to their sons or on contrary fathers officially maintaining their land rights while their sons farm the land, suggesting other ways to land access than official wealth transfer from family or government. Within families, siblings reported different roles according to birth-order rank. Elder sons were expected to take care of younger siblings, and, when possible, to offer some large gift (i.e.: a cow) for younger brothers' wedding. Younger brothers, on the other hands, were expected to be obey older siblings and to serve them back through labour. Finally, some informants specified that last-borns were expected to remain with their parents and care for them as they age; this, in turn, might increase their access to their parents' land. The education level is relatively low, with few individuals finishing high-school education outside the village (11.9% and 19.4% of the redistribution and inheritor groups, respectively). Finally, some impoverished villagers labored as daily workers for other farmers. Non-agricultural jobs in the villages were rare and consisted mostly of governmental jobs or religious jobs. Non-agricultural cash-generating activities (local business, crafts) mostly served as side income to farming and were not widespread.

Recruitment

All households in the villages were visited and heads of households (hh) were interviewed (N=590). Multiple visits were sometimes necessary and only a few households (<10) were not recruited due to the long-term absence of their head of household. Because the study communities are patriarchal, patrilineal and patrilocal and present strong gender roles and enforce strong gender roles for socio-economics activities, which likely affects people's social networks, we focused on male head-of-household support

network. Support networks considered here include daily supports for farming and domestic activities in a broad, such a help with farm activities (ploughing, seeding, weeding, cattle care, and gifting or loan of seeds, crops, and other materials including animals), help with domestic activities (gifting or loan of food, clothes, money, water, firewood, or other materials), help during sickness (transport or care), help with house construction, and ceremonial duties. Because first-born and last-born sons might enjoy some extra-parental investment (Kidwell 1982, Hertwig, Davis and Sulloway 2002, Faurie, Russel and Lumma 2009), and because birth rank does not discriminate for the last-born category, we used three intra-sex birth-order categories (firstborn, middle born and lastborn sons) instead of birth rank. Thus, only heads of household with at least two brothers born from the same father, who survived until fifteen years old, were included in the models (N=331). Only farmers owning land rights were included, to focus on the impact of wealth transfers. Landless male farmers generally worked for other farmers, joined another household or, increasingly, moved to the city; these men likely had very different social characteristics compared with landowners.

Procedures

The Ethics Committee of the University of Bristol approved all study materials and methods. Research permits were obtained from national, regional, zonal, and local Ethiopian authorities. All participants were informed about the nature of the study, data confidentiality, and of their rights to withdraw at anytime. Participants were required to either sign or fingerprint an informed consent document before participating. A pilot study was organised in a similar neighbouring community, to confirm that the questions were appropriate for the local context (e.g., non-sensitive and understood by the local community) and to identify any erros in translation or terminology. Our mixed-methods data collection approach included questionnaires, focus group discussions and semi-directed qualitative interviews. Interviews and semi-structured questionnaires following standard anthropological data collection (Fowler 1995; Krosnick and Fabrigar 1997; Bernard 2002) were undertaken. A team of seven fluent Amharic-Oromic speakers collected questionnaires from the heads of households. Questionnaires were translated from English to Oromic and then back translated. A fluent Amharic-Oromic-English speaker assisted with all interviews and focus group discussions.

Subsamples

The Marxist revolution, which resulted in a massive land confiscation and land redistributions, in 1975, 1988 and 1990, allows for a natural experiment to study two farmer groups who received land from different sources, one from the government through the PAs and the other from their family. Because farmers did not all marry and start a family at the same age, some men from the older generations were excluded from governmental redistribution and some from the younger generation who married very early might have benefited from it. Individuals who were not part of the PA for any reason might have been excluded from governmental land access. Patterns of land transfer can be complex, however, the vast majority of men received land rights through similar pathways as their generational peers. Participants in the older group (>40 years old) mostly received their land rights from government land redistribution (redistribution farmers). 93.4% received land rights from the government. Some received it from their family (6%), and only one bought it with credit. Some men had parents who received land from governmental redistribution; thus, they might receive inheritance upon their parents' death, thus accumulating land from the government and from their family, but only a small proportion already received both government and family land (9.3%). However, most men in the older generation received land parcels equal in land and quality from the government. Respondents of the younger group (<41 years old) mostly obtained their land after the last governmental land redistribution, and where thus, dependent upon their parents (=inheritor farmers) for land access. 89.4% received land from their families. 10% received land from the government only. Only one farmer bought it. A small proportion received land from both their family and the government (10%).

Data

Socio-economic, demographic and support network data about households and household heads were collected with questionnaires during interviews. Support network data were generated from both questions: 1) Whom do you help on a daily basis for agricultural and domestic support? 2) Who are your daily helpers for agricultural and domestic support? For both questions, respondents gave the person's full name, relationship, place of residence, and type of support provided. When the same person was cited for both responses, we labeled the contact as a (direct) reciprocator, when the person was cited for only one answer;

we labeled the contact a non-direct reciprocator. Herein, we define reciprocity as here current direct reciprocity at the time of data collection; and we define non-direct reciprocity as all other bi-directional interactions (e.g., contingent reciprocity on longer timescale) or unidirectional (altruism or indirect reciprocity, which are difficult to discriminate from each others). We preferred the terminology "non-direct reciprocity" over "altruism", because it includes indirect reciprocity (through one, several or many peers), and also delayed reciprocity. Degrees of reciprocity were too complex to be measured, for example, help received and given might or might not be of equal value, intrinsically or relatively to the mutual interactants (considering each person's age, wealth or social status, physical condition, energy needs and expenditure etc.), nor of perceived equal value. We extracted the network configuration (presence or absence of support -received and/or given) and support network size (number of supporters or number of persons helped) from each participant's responses.

Respondent age, farmland size (ha), village (1 or 2), parents being alive or deceased and number of brothers or sibling who survived to 15 years old were included in the models when possible.

Because there are redundancies across religious affiliation and ethnicity (Amara and Shoa Oromo are Christians, while Arsi Oromo are Muslims), religion (Christians/Muslims) was preferred as a main-effect variable over ethnicity (Shoa/Arsi/Amara) because it better represents the between-group differences in among the participants. We also included education level (finished high school education/not) in our models.

Farmers from village 1 have significantly smaller plots of land (1.24±1.06) compared to village 2 (1.70±1.20; Mann Withney U Test: U=9848.00, z=-4.091, p=0.0001), they also reported (mean±sd=3.10±1.47) significantly smaller network sizes than village 2 farmers (3.69±1.18, Mann Whitney U test, U=10322.00, z=-3.614, p=0.000), which is why we discriminated between villages 1 and 2 in the models.

Some studies have suggested that of network size and structure remain relatively consistent across the lifespan, despite individual variations (e.g. Dunbar 2008). Those variations might affect network composition and network size, which is why we also explored age (Hill and Dunbar 2003) and wealth effects. For example, young parents might receive more support from kin for domestic work and might require more support from experienced and older farmers. Young people might be capable of providing

more support due to their youth and physical strenght, while people might begin to receive support as they age.

Connections between material capital and social capital have been shown many times (Lewis 2010). We choose farmland size as a proximate for material capital, because it is a key resource in our study for survival and reproductive outcomes (Gibson and Gurmu 2011) was chosen. Previous pilot studies showed that wealth oriented questions were sensitive. Indeed, we found that farmers were uncomfortable answering questions about wealth, but accepted questions about the size of their land, which is public knowledge anyway. Questions about livestock appeared to be fairly sensitive.

Thus we narrowed our questions about wealth to farmland size. Because most of the farming is agricultural a focus on farmland size was adequate, especially considering that both villages had similar ecologies and agro-systems. Furthermore, because farmers use oxen for animal traction to work the land, the number of oxen owned is usually proportionated to the farmland size.

Variation in farmland size is reduced (range: 0.25-5ha only), probably because the last Marxist redistribution was fairly recent (1992), and it may be that not enough time has passed for inequalities to grow. However, because social capital includes a collective dimension through interactions between community members, it was relevant to consider respondent relative wealth in their village. We tested for an interaction effect between land size and village, but we did not include them in final models when they yielded non-significant results.

Database and data analyses

Socio-economic, demographic, and social-network data were input in into a Microsoft Access (Redmond, WA, USA) database. IBM SPSS Statistics for Macintosh, version 22.0. software was used for all analyses. (IBM, Armonk, NY, USA). We created one large data frame that included socio-economic, demographic, and network size and composition data for each respondent. Descriptive statistics are presented in the appendix.

Generalized linear models with Poisson regressions were fit to compare birth-order categories effects on full network size, kin network size, non-parental kin network size, number of non-parental kin reciprocators and number of non-kin reciprocators. Independent variables were: age, land size, village, religion,

education, sibling size or male sibling size, land origin, and generational group. Estimated marginal means are presented in the figures.

We fit logistic regressions with independent variables to identify effects of birth-order categories associated with parental interactions among farmers' support networks. We only performed analyses of parent interactions for the inheritor group, because a large proportion of the redistribution group (respondent>40 years old) have elderly or deceased parents or deceased parents (87% of the inheritor group had at least one parent being alive, for 36% of the redistribution group). Logistic regressions were performed for three types of interactions: 1) parents cited as interactants (helpers or receivers) 2) parents are named as helpers 3) parents are named as reciprocators. Independent variables we included in the models were: age, education, religion, land size and respondent village, intra-sex birth-order categories, and survival of at least one parent/none.

Wilcoxon signed ranks tests were performed for respondents of both groups to compare the number of kin to the number of non-kin, the number of close kin (parents, children and sibling) to the number of distant kin (other kin).

Results

We estimated that mean (± sd) network sizes for domestic and agricultural interactions were 3.48±1.24 for the inheritor group and 3.18±1.51 for the redistribution group. Two major trends emerged from our analyses: 1) Support networks varied according to competition among brothers and 2) reciprocity and kin-selection shaped farmers' daily support networks.

Prediction 1: Support networks varied according to birth-order biases

We fit GLMs with Poisson regression to explore the impact of intra-sex birth order on network size and kin network size, while controlling for age, number of male siblings, land size, and village (Table 1). In model 1, only village had an effect on total network size (kin and non-kin), where village 1 respondents reported smaller networks than village 2 respondents (village 1/2 ratio: expB (95% CI)=0.8 (0.7–1.0), P=0.010). When focusing on the number of kin cited (model 2), an intra-sex birth-order effect was present among first-born sons (expB (95% CI)=1.5 (1.1–2.0), P=0.005) and middle-born sons (expB (95% CI)=1.5 (1.2–2.0), P=0.002) who both reporting more kin than last-born sons. Because the law states that both males and females can inherit, a similar model that includes birth order for all children instead of just brothers was tested (Model 4, Table 1), but no significant birth-order effect was observed, suggesting that indeed intra-sex birth order is a better measure of competition than overall sibling birth order.

Age did not have a significant effect on network size in the above models. However, when we discriminated between the inheritor and redistribution generations and when we controlled for an interaction effect between generation and birth order, significant differences in kin network sizes were observable according to birth-order categories (Table 1, Model 3, Figure 1), with first-born sons of the inheritor group and middle-born sons of the redistribution group having the most kin in their networks.

Fig. 1 Number of kin, listed in support networks, presented as marginal means +SE (N=331) for each intra-sex birth-order categories (first, middle and last-born sons) and generations (inheritor and redistribution groups). Covariates appearing in the model are fixed at the following values: male sibling size=5, land size=1.43ha. Controlling for village and generations (inheritor vs. redistribution group). FB=first-born, MB=middle-born, LB=last-born

Across generation, kin accounted for over half of the people in respondents' networks (57.1% and 51.2% for the inheritor and redistribution groups, respectively, Table 2). Interactions with parents accounted for 17.1% and 6.0% of respondents' total interactions for the inheritor and redistribution groups, respectively. Interactions with non-parental kin (40.0% and 45.2% overall for the inheritor and redistribution groups, respectively) were distributed as follows: 22.5% and 17.7% were with brothers, 0.6% and 15.8% were with children, and 4.5% and 2.3% were with sisters. The small proportion of daily interactions with sisters is due to the local custom of women marrying outside their community.

To understand how direct reciprocity and non-direct reciprocity contribute to individual support networks, different types of interactions were explored for each of the main interactant categories, which included parents and non-parental kin.

1.1 **Interactions with parents**

Among the inheritor farmers (n=180), 55% named at least one parent as an interactant, and half of those reported a reciprocating relationship (n=49). Reciprocal relationships with parents were reported by 67.4%, 47.6%, and 61.3% of first-born, middle-born, and last-born sons, respectively. Parents as helpers were reported by 43.5%, 27.2%, and 29.0% of first-borns, middle-borns, and last-borns, and 63.0%, 45.6% and 58.1% reported helping a parent. Middle-born sons reported parent interactants significantly less often than other sons (likelihood-ratio=5.416, df=1, P=0.020), because first-born sons reported a parent helper (likelihood-ratio=3.855, df=1, P=0.050) and a reciprocating parent ((likelihood-ratio=4.227, df=1, P=0.040) most often, while middle-born sons reported helping their parents less than other sons (likelihood-ratio=4.216, df=1, P=0.040).

As expected, when controlling for birth order, village, religion, and having a living parent among farmers in the same generation, younger farmers were more likely to cite parents in their networks than older farmers (age: OR (95% CI)=0.9 (0.8–1.0), P=0.025; Model 1, Table 3).

Consistent with our expectations, we also found a first-born positive bias in citing parents in networks. However, when comparing birth-order categories, middle-born sons were significantly less likely to cite a parent in their network compared with first-born sons (OR (95% CI)=0.4 (0.2–1.0), P=0.045), but we found

no significant difference between first- and last-born sons (OR (95% CI)=0.8 (0.3–2.3), P=0.726; Model 1, Table 3). These results suggest that first- and last-born sons are more likely to have parent interactants than middle-born sons.

Parents invest in their children in various ways, providing, for example, education and material wealth. When education and land-size transfers were included in the model, evidence for birth-order biases were insignificant (OR (95% CI)=0.5 (0.2–1.1), P=0.075 and OR (95% CI)=0.9 (0.3–2.6), P=0.841; Model 2), suggesting that daily interactions with parents might not be biased in favour of birth order when other types of investment are controlled for. Farmers who completed high school were significantly morel likely to report their parents as interactants compared with other farmers, (OR (95% CI)=4.0 (1.5–10.7), P=0.006; Model 2). Finally, we found no birth-order biases among sons reporting a parent as a reciprocator (OR (95% CI)=0.5 (0.2–1.1), P=0.101 and OR (95% CI)=0.5 (0.2–1.5), P=0.241; Model 3) or among sons reporting a parent as a direct supporter (OR (95% CI)=0.5 (0.2–1.1), P=0.095 and OR (95% CI)=0.5 (0.2–1.4), P=0.172; Model 4).

1.2 Non-parental kin and non-kin support

Non-parental interactions comprised an important component of social-support networks in our dataset: 42.28% of interactants were non-parental kin, including 40.03% among the inheritor group and 45.21% among the redistribution group.

GLMs with Poisson regression revealed a significant difference in the total number of non-parental kin interactants cited by inheritor farmers across the three different birth-order categories, controlling for age, number of male siblings, land size, village, education, and religion. We observed a decrease in the number of non-parental kin cited with successive birth-order categories (Fig. 2). Middle-born and last-born sons reported fewer non-parental kin in their networks compared with first-born sons (expB (95% CI)=0.7 (0.6–1.0), P=0.062, expB (95% CI)=0.5 (0.3–0.8), P=0.003, reciprocally). None of the control variables had a significant effect on model fit (Table 4). Those birth-order biases appeared to result from non-direct-reciprocal interactions. There was not a significant difference in reporting reciprocators among sons of different birth-order categories (reciprocally expB (95% CI)=0.9 (0.6–11.4), P=0.817, (expB (95% CI)=0.7 (0.4–1.3), P=0.257). Among the control variables, only village had an effect, with respondents from village 1 reporting fewer reciprocators than those in village 2 (expB (95% CI)=0.6 (0.4–09), P=0.018).

Fig.2 Effect of intra-sex birth-order categories on the number of non-parental kin cited in daily support networks for the two groups.

Fig.2a Number of non-parental kin cited presented as marginal means (+SE); n=180, first-born sons (FB) n=46; middle-born sons (MB) n=103, last-born sons (LB) n=31. Covariates appearing in the model are fixed at the following values: number of male siblings=5.07, land size=0.64 ha, age of respondent=31.48 years. We controlled for religion, education level, village, and land origin

Fig.2b Number of non-parental kin cited are presented as marginal means (+SE); n=151, first-born sons (FB) n=48; middle-born sons (MB) n=79; last-born sons (LB) n=24. Covariates appearing in the mode are fixed at the following values: number of male siblings=4.91, land size=2.38 ha, respondent age =57.75 years. We controlled for religion, education level, land origin, and village

Results for the redistribution group followed a different pattern, where we found significant differences across the three birth-order categories. First- and last-born sons reported fewer non-parental kin in their networks compared with middle-born sons (expB (95% CI)=0.6 (0.5–0.9), P=0.010 and expB (95% CI)=0.5 (0.3–0.8), P=0.004). Only religion had a significant effect as a control variable, with Christians having larger networks than Muslims (expB (95% CI)=1.8 (1.0–3.1), P=0.045). Due to our small sample size, pairwise comparisons of the estimated marginal means were run for middle-born sons compared with other birth-order sons for both religions. Similar patterns were noticeable for Christians and Muslims, with middle-born sons citing more non-parental kin compared with other sons (Christians: mean difference (middle-born vs. other sons)±SE=0.61±0.19, P=0.001; Muslims: mean difference (middle-born vs. other sons)±SE=0.35±0.16, P=0.016). Religion did not impact patterns of birth-order biases. Birth-order biases in non-parental kin network size were dependent of non-reciprocal interactions as we found no significant differences in the number of reciprocators according to birth order (expB (95% CI)=1.0 (0.6–1.6), P=0.924 and expB (95% CI)=0.9 (0.5–1.8), P=0.814). When controlling for all other variables, village, high-school education, land size, and land origin (redistribution vs. inheritance) had a significant effect on the number of reciprocators. Farmers from village 1 reported fewer reciprocators (expB (95% CI)=0.5 (0.3–0.8),

P=0.009), as did farmers without a high-school education (expB (95% CI)=0.3 (0.2–0.7), P=0.002). Farmers with larger land holdings reported more reciprocators (expB (95% CI)=1.4 (1.0–1.8), P=0.027), and, finally, farmers who did not receive land from family reported having more reciprocators (expB (95% CI)=2.0 (1.0–4.2), P=0.050).

Prediction 2: Reciprocity and kin-selection shape farmers' daily support networks

The inheritor group cited more kin than non-kin (z=-2.455, P=0.014, Wilcoxon signed-rank test), while the redistribution group cited as many kin as non-kin (z=-0.236, P=0.814). A substantial component of kin interactions was based on daily direct reciprocity: 49.7% of kin interactions of the inheritor farmers and 37.4% of kin interactions of the redistribution farmers were direct-reciprocal interactions, which suggests the importance of direct payoff even with kin.

Respondents reported significantly more close-kin reciprocators than distant-kin reciprocators (N=331, z=-8.849, P<0.0001, Wilcoxon signed-rank tests), suggesting that reciprocity with close kin might be favoured because of the compound profits of direct-reciprocity payoffs and indirect-fitness payoffs from kin selection. Both farmer groups reported significantly more reciprocal interactions with close kin than distant kin (inheritor farmers: n=180, z=-6.313, P<0.0001; redistribution farmers: n=151, z=-4.857, P<0.0001, Wilcoxon signed-rank tests).

Farmers reported significantly more non-reciprocal interactions with kin than with non-kin (all respondents: N=331, z=-5.545, P<0.0001; inheritor group: n=180, z=-4.402, P<0.0001; redistribution group: n=151, z=-3.444, P=0.001, Wilcoxon signed-rank tests). They also reported significantly more non-reciprocal interactions with close kin than with distant kin (all respondents: N=331z=-8.296, P<0.0001; inheritor group: n=180, z=-5.727, P<0.0001; redistribution group: n=151, z=-6.025, P<0.0001,Wilcoxon signed-rank tests). This trend held when considering only non-reciprocal helpers: farmers reported significantly more non-reciprocal kin helpers than non-reciprocal non-kin helpers (all respondents: N=331, z=-2.545, P=0.011) and significantly more close-kin non-reciprocal helpers than distant-kin non-reciprocal helpers (all respondents: N=331, z=-4.762, P=0.0001).

Discussion

The findings from this natural experiment allow us to identify patterns of intra-household inequalities in terms of support networks for two wealth transmission modalities. Where material wealth is inherited, support network inequalities follow patterns of material inequalities, like the ones observed by Gibson and Gurmu (2011), suggesting that social capital in support networks reinforces material inequalities between brothers in the context of limited resources. When wealth is not inherited and all sons had equal access to land, other patterns of support network biases appeared, suggesting that social capital might at least partly offset the disadvantage of sons receiving the least cumulative parental investment, which is consistent with findings from Salmon (2003), Rhode et al. (2003), Salmon and Daly (1998). Overall, our findings suggest that heritable wealth and land transfers, by influencing material and social capital, might have an important role in the emergence and persistence of inequality in this agricultural population, similar to findings by Smith et al. (2010). Our findings also imply that direct reciprocity appears to explain an important part of kin cooperation, providing additional support for a more nuanced explanation of kin cooperation compared with sole kin selection, as found in a number of different contexts (Jaeggi and Gurven 2013). Here, support-network sizes were consistent with predictions from the literature, particularly Dunbar's work on biological constraints on human social networks, which predicts that "natural" support-network sizes range from 3–5 people (Dunbar & Spoor 1995, Zhou et al. 2005, Hamilton et al. 2007).

Prediction 1: Birth-order biases in support-network size and composition

We found strong evidence of kin-selection, coinciding with multigeniture with a first-born son advantage, in the inheritor group. First-born farmers were more likely to name parents as daily support partners, particularly as reciprocators. Thus, first-borns preferentially received parental investment, but also, by reciprocating, reduced their parents' potential kin-selection costs. However, when controlling for other variables, this effect was weaker and, at best, an insignificant tendency. Non-parental kin support size was biased toward first-born sons, an effect that was not driven by reciprocity. This pattern reveals that first-born farmers are advantaged in terms of both material (Gibson and Gurmu 2011) and social capital, which decreases their household vulnerability relative to other farmers. We also found that middle-born and last-born sons diversified their networks by reciprocating with more non-kin compared with first-born sons. Meanwhile, middle-born farmers in the redistribution group were more advantaged in terms of their support

networks, possibly because they diversified their networks to include more non-parental kin (Salmon and Daly 1998, Salmon 2003, Rhode et al. 2003). Middle-born farmers reported more non-parental kin in their networks than did other farmers, and these interactions were mostly characterized by non-direct reciprocal interactions, suggesting other non-exclusive mechanisms than direct reciprocity, such as kin selection, delayed reciprocity, or indirect reciprocity. For both groups, last-born sons were among the most disadvantaged in terms of their kin-support networks, as they reported fewer kin than other inheritor farmers. According to Gibson and Gurmu (2011), "the number of elder brothers reduces a man's agricultural productivity, marriage, and reproductive success, as resources diminish and competition increases with each additional sibling." Thus, a last-born disadvantage in material resources and fitness was sufficiently impactful to generate a negative bias in daily kin support and to drive last-borns to diversify their network to non-kin through reciprocity. A negative kin bias might be even more dramatic for last-born sons who had no land access, possibly forcing them to leave their community for low-skilled jobs in urban centres.

Last-born farmers from the redistribution group were also disadvantaged. Alongside first-born sons, they reported less non-parental kin support compared with middle-born sons, but they tended to report more diversification via reciprocity with non-kin compared with their brothers. These results suggest a possible continuity of first-born son preference during the redistribution period, which might not have been entirely offset by the governmental land redistribution. Despite sweeping redistribution policies of the revolution-era government, evidence suggests that not all intra-household and inter-household resource inequalities were dismantled. Our focus group discussions and qualitative-interview informants told us that the socio-economic statuses of families in past generations were still important for arranging marriages. Brothers might not have had to compete for a critical livelihood resource because they all received equal plots from the government, but there are other pathways through which sibling competition could arise. On the one hand, a first-born son advantage could persist into later years, which could lead to first-born sons being more family oriented and less non-kin oriented than other sons. On another hand, last-born sons might work harder and take more risks to build non-kin relationships through direct reciprocity, which is consistent with farmer comments during focus groups. Last-born sons were said to be "more difficult to discipline" in younger ages, but also more "free, more rebellious, more obstinate, more friend-oriented, and

also more risky and adventurous," compared with their older brothers. Sulloway (1996) claimed that parental investment and sibling competition create a niche effect during childhood that influences construction of personality and sociability constructs that persist into adulthood. Other studies have investigated the influence of family size and composition on personality and social attitudes at young ages (Salmon and Daly, 1998, Salmon 2003); some of these studies found that biases persist into adulthood when offspring are less dependent on parental investment (Salmon 1998), but others found that parental-investment biases are less influential (Pollet and Nettle 2009) or absent (Rhode et al. 2003, Pollet and Nettle 2007, 2009) in adulthood, possibly because of adjustments in support-network configuration over a lifetime. We observed significant biases among adult farmers in our study sample, suggesting the importance of material and social resources in shaping support.

Respondent age tended to affect network size, probably only because parents were more often cited as interactants by the younger-generation farmers. Age was not associated with non-parental kin and non-kin interactions, even when we evaluated the two generations separately. Within the inheritor group, younger farmers were expected to interact more with kin than older farmers, because they had higher reproductive value, probably had less agricultural experience, had less labour power within their households because their children were still very young, and had younger parents with more ability to help. On the one hand, older farmers in the redistribution group could be expected to interact with more people generally, including kin, because of their elder status; on the other hand, they could be expected to interact with fewer people, because they have les ability to reciprocate support. Our results suggest that compositional changes in agricultural and domestic interactions, rather than network size changes, might occur during farmers' lifetimes; such compositional changes include interactant identities, interaction type, and direction of interaction.

We also found that religion, education, and village had a significant effect on networks, revealing the importance of individual and community context. Muslims were a minority in the study villages, so they might have had fewer kin in their village and might have had a preference for Muslim interactants; hence, Muslim inheritors would have fewer non-parental kin and redistribution farmers would have fewer non-kin reciprocators than Christians. High-school education appears to be an attractive characteristic for reciprocity among non-parental kin, in the context of equal land access, because high-school educated

farmers from the redistribution group reported more non-parental kin reciprocators. Finally, we observed a significant village effect, with farmers from village 1 reporting significantly smaller networks compared to farmers in village 2.

In this population, wealth, as measured by land size, did not seem to influence farmers' networks, apart from the number of non-parental kin reciprocators in the redistribution group, suggesting that origin of land access (inheritor vs. redistribution) was more impactful than land size on kin investment in daily support networks. Land size among our sample was fairly homogenous and the variance was small; furthermore, only landowners were included and they were all from large families with at least three sons. Because of unmeasured informal arrangements for land access (Gavian and Ehui 1999), official land size might be an underestimated proxy for the actual land size used for production. Therefore, it might be fruitful to explore other types of wealth. Cues about the connection between support networks and material resources, especially in difficult times, have been identified. For example, Caudell, Rotolo and Grima (2015), showed that, among the Sidamo people of southern Ethiopia, charismatic individuals in informal lending networks were wealthier than other farmers in terms of cattle herd size. Other work, identified non-linear wealth dynamics on the formation of informal insurance networks, with the poorest being excluded from those networks (Santos and Barrett 2006).

However, in our pilot work in the study site, low variation was observed in herd sizes. Farmers used a pair of oxen to work their land, and might have two pairs if they have larger land holdings. Thus, more complex indexes might be necessary to evaluate wealth. It is also possible that resources might have a smaller impact on daily interactions compared with their impact on insurance networks, where resources increase resilience in difficult times.

Prediction 2: Reciprocity and kin-selection shape farmers' daily support networks

Our results showed that kin make up an important proportion of support networks, which is consistent with kin-selection theory (Hamilton 1964). In small-scale societies, close kin are overrepresented compared with distant kin and non-kin (Gurven et al. 2000, Patton 2005). Kin over-representation is also visible in Western societies (Dunbar and Spoors 1995). However, reciprocity (including reciprocal altruism as per, Trivers 1971) plays an important role in shaping support ties among kin (Patton 2005, Gurven et al. 2000). For instance, Hames (1987) suggested that, in Venezuela, "the Ye'kwana system of garden labour

exchange is a form of reciprocity biased by kinship." Additionally, food transfers on an Ache reservation in northeastern Paraguay "accords better with reciprocal altruism theory than with kin selection theory" (Allen-Arrave, Gurven and Hill 2008). Finally a meta-analysis of 23 studies from 32 populations of humans and primates highlighted the importance of reciprocity on shaping cooperation, and demonstrated that the relative effect of reciprocity for sharing was similar to those of kinship and tolerated scrounging (Jaeggi and Gurven 2013).

Non-reciprocal interactions should be more common among kin than non-kin, and among close kin than distant kin, because of indirect fitness payoffs. Reciprocity theory (Trivers 1971) potentially explains most interactions with non-kin, as well as many kin interactions, especially distant kin with whom indirect-fitness profits from helping behaviour are relatively lower (Hames 1987, Gurven et al. 2000, Allen-Arrave, Gurven and Hill 2008). We expected most non-kin interactions to be reciprocal, but expected more variation in reciprocity among kin interactions. In fact, support networks constituted multi-directional interactions: respondents stimulated and modulated their support by lowering the giver's costs through some amount of daily direct and indirect reciprocity. Interestingly, kin were frequently included in reciprocal relationships, even though the frequency of non-reciprocal interactions among kin increased with genetic relatedness. Delayed (contingent) reciprocity, which is difficult to evaluate and identify, might have been mistaken in our dataset for non-reciprocal interactions, and so there may be even more variations and higher quantities of reciprocal relationships among these farmer communities. According to these results, even when considering classification of direct reciprocity/non-direct reciprocity and even when the last category includes contingent (delayed) and indirect reciprocity (through another person), patterns for non-reciprocal interactions followed predictions of kin selection while reciprocity, alongside kin selection, appeared to be an important driver of daily reciprocal kin interactions. In other words, kin selection does not appear to be the sole explanation for support received from kin.

Conclusion

Two major implications can be drawn from our findings in this natural-experiment context. First, we were able to understand how heritable wealth shapes daily support networks in a contemporary agricultural community and how it contributes to intra-household inequality. Our findings are consistent with Smith et

al (2010) and Boone (1992) who concluded that the control and transmission of scarce inelastic wealth, such as farmland, was an important factor in the emergence of inequality.

Second, in this small-scale land-based community, both kin selection and reciprocity shaped adult farmers' daily support networks, suggesting that reciprocity is important for cooperation among kin, as also shown by Jaeggi and Gurven (2013) in a number of contexts.

Our findings shed light on the behaviour and evolution of human social interactions by showing that people and their kin adjust their daily support behaviour in a complex manner that is consistent with fitness predictions. Increased socio-demographic and economic changes are expected in Ethiopia. Contraception has recently become more widespread (Alvergne et al. 2012), leading to a smaller average family size, which might change future intra-household resource distribution by reducing resource dilution. However, because of on-going population growth, land erosion, and limited arable land (Tefera et al. 2002)—all of which will only grow more serious with climate change and geo-political instability—resource scarcity and livelihood insecurity are likely to increase and further aggravate competition and inequalities, within and between households. Some individuals will likely have greater resilience in times of shock because they can rely on their networks (Caudell, Rotolo and Grima 2015), while the poorest and most vulnerable might not have the social resources to respond (Santos and Barrett 2006) and may be pushed to urban areas.

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Biosketch

Does kin-selection theory help to explain support networks among farmers in South-Central Ethiopia?

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Lucie Clech obtained a PhD in Evolutionary Anthropology from the University of Bristol, focusing on human behavioural ecology of migration in Ethiopia, before undertaking postdoctoral research at Stanford University. Her research covers topics about poverty and family dynamics and includes migration, social interactions, education and health in resource-limited communities. Her interdisciplinary background in ecology and social sciences led her to focus especially on dynamics of livelihood strategies in response to modifications in their socio-economic and demographic environment.

Ashley Hazel holds a PhD in Natural Resource Ecology from the University of Michigan, and she is currently a Research Scientist at Stanford University in the Department of Earth System Science. Her research interests include human disease ecology, social network theory, and subsistence migration.

Mhairi Gibson is an Associate Professor in Anthropology at the University of Bristol. As an applied evolutionary anthropologist her work applies ideas from human behavioural ecology to emerging population health issues in low-income settings. Her fieldwork-based research has explored the causes and consequences of human population and health change in rural Ethiopia, and the social dynamics of normative practices which are harmful to women. Mhairi Gibson was lead editor (with David Lawson) of 'Applied evolutionary anthropology: Darwinian approaches to contemporary world issues', published by Springer Science & Business Media (2014).

Tables

Does kin-selection theory help to explain support networks among farmers in South-Central Ethiopia?

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Table 1. GLMs with Poisson regression for network size (model 1) and kin network size (model 2,3,4). N=331.

Models:	Model 1		Model 2		Model 3		Model 4	
	ExpB(95%CI)	P	ExpB(95%CI)	P	ExpB(95%CI)	P	ExpB(95%CI)	P
Intercept	4.4(3.4-5.7)	0.000**	1.8(1.2-2.6)	0.004**	1.7(1.2-2.5)	0.003**	2.2(1.5-3.4)	0.000**
Age of respondent (years)	1.0(1.0-1.0)	0.067	1.0(1.0-1.0)	0.282			1.0(1.0-1.0)	0.365
BO: First-born children(/last)							1.2(0.8-1.6)	0.361
BO: Middle-born children(/last)							1.2(0.9-1.6)	0.225
Sibling size (males and females)							1.0(1.0-1.0)	0.273
BO: First-born sons (/last)	1.0(0.8-1.2)	0.715	1.5(1.1-2.0)	0.005**	1.5(1.1-2.1)	0.015*		
BO: Middle-born sons (/last)	1.08(0.9-1.3)	0.362	1.5(1.2-2.0)	0.002**	1.2(0.8-1.6)	0.344		
Number of male siblings	1.0(1.0-1.0)	0.708	1.0(0.9-1.0)	0.943	1.0(1.0-1.0)	0.961		
Village 1 (/2)	0.8(0.7-1.0)	0.010**	0.9(0.8-1.1)	0.200	0.9(0.8-1.1)	0.348	0.9(0.7-1.0)	0.160
Land size (ha)	1.0(0.9-1.1)	0.532	0.9(0.8-1.1)	0.475	1.0(0.8-1.1)	0.532	0.9(0.8-1.1)	0.394
Generations (redist/inheritor)					0.6(0.3-1.0)	0.048*		
Firstborn sons*generations (redist/inheritor)					1.0(0.5-1.8)	0.981		
Middleborn sons*generations (redist/inheritor)					2.0(1.1-3.5)	0.014		

Notes: There was no interaction effect between land size x village, so they were not included in the models. Model 1=number of interactants cited in networks, model 2, 3, and 4=number of kin interactants cited in networks. Model 3 is a variation of model 2 and includes generational group and an interaction effect BO*generational group. Model 4 includes birth-order categories instead of intra-sex birth-order categories. * p=0.05 **p=0.01

Table 2: Distribution by interactant relatedness

		Interactants (% for all interactants)								
	Total number of interactants	Non-kin	All kin	Parents	Non -parental kin	Close kin	Brothers	Sisters	Children	Distant kin
All	1107	45.44	54.56	12.28	42.28	43.45	20.41	3.52	7.23	11.11
Inheritor group	627	42.90	57.10	17.06	40.03	44.66	22.49	4.46	0.64	12.44
Redistribution group	480	48.75	51.25	6.04	45.21	41.87	17.71	2.29	15.83	9.37

Note: Distant kin include kin and in-laws who are not parents, siblings, or children.

Table 3: Logistic regressions for reporting at least one parent in their network.

Models:		Model 1			Model 2			Model 3			Model 4		
		OR(95%CI)	P		OR(95%CI)	P		OR(95%CI)	P		OR(95%CI)	P	
Age of respondent	180	0.9(0.8-1.0)	0.025	*	0.9(0.8-1.0)	0.011	*	0.9(0.8-1.0)	0.010	**	0.9(0.8-0.9)	0.002	**
Intrasex birth-order categories			0.095			0.141			0.233			0.200	
Middle-born(/first)	103/46	0.4(0.2-1.0)	0.045	*	0.5(0.2-1.1)	0.075		0.5(0.2-1.1)	0.101		0.5(0.2-1.1)	0.095	
Last-born(/first)	31/46	0.8(0.3-2.3)	0.726		0.9(0.3-2.6)	0.841		0.5(0.2-1.5)	0.241		0.5(0.2-1.4)	0.172	
Number of male siblings	180	1.0(0.8-1.2)	0.847		1.0(0.8-1.2)	0.940		0.9(0.8-1.2)	0.638		0.9(0.8-1.1)	0.522	
High school educated (/not educated)					4.0(1.5-10.7)	0.006	**						
Land size (ha)	180				1.0(0.5-12.0)	0.905							
Village 1(/2)	105/75	0.4(0.2-0.9)	0.030	*	0.4(0.2-0.8)	0.014	*	0.4(0.2-0.9)	0.026	*	0.6(0.3-1.2)	0.129	
Christians (/Muslims)	143/37	0.5(0.2-1.2)	0.119		0.4(0.2-1.1)	0.092		0.8(0.3-2.5)	0.846		0.6(0.2-1.4)	0.242	
Land provided by the family (/not)					1.3(0.4-4.1)	0.635							
Constant		16.904	0.072		25.0	0.089		14.058	0.128		32.7	0.039	*

Notes: Logistic regressions for models 1and 2: citing at least one parent in their network, model 3: reciprocating with at least one parent and model 4: reporting support from at least one parent. Model 2 is a variation of model 1 and includes different types of parental investment (land size, land transferred and education). Controlling for having at least one alive parent. * p=0.05 **p=0.01

Table 4: GLMs with Poisson regression for the number of non-parental kin cited, non-parental kin and non-kin reciprocators for the two generational groups.

	Number of non-parental kin cited in support network						
	Inheritor group (n=180)				Redistribution group (n=151)			
	n	expB(95%CI)	P		n	expB(95%CI)	P	
Intercept		2.2(0.7-7.1)	0.180			0.8(0.3-2.2)	0.654	
Age of respondent (years)	180	1.0(1.0-1.0)	0.770		151	1.0(1.0-1.0)	0.662	
Bo: middle-born(/first-born sons)	103/46	0.7(0.6-1.0)	0.062					
Bo: last-born(/first-born sons)	31/46	0.5(0.3-0.8)	0.003	**				
Bo: first-born (/middle-born sons)					48/79	0.6(0.5-0.9)	0.010	**
Bo: last-born (/middle-born sons)					24/79	0.5(0.3-0.8)	0.004	**
Number of male siblings	180	1.0(0.9-1.0)	0.621		151	1.0(0.9-1.1)	0.787	
Land size(ha)	180	1.2(0.9-1.5)	0.196		151	0.9(0.8-1.1)	0.552	
Village 1(/2)	105/75	1.1(0.8-1.4)	0.586		88/63	0.8(0.6-1.1)	0.201	
High school education (not educated/educated)	145/35	0.9(0.6-1.2)	0.367		133/18	1.2(0.7-2.1)	0.388	
Christians/Muslims	143/37	1.0(0.7-1.4)	0.900		134/17	1.8(1.0-3.1)	0.045	*
Land origin (not from family/from family)	19/161	0.7(0.4-1.1)	0.169		128/23	1.3(0.8-2.0)	0.238	

Number of non-parental kin reciprocators in support network

	Inheritor group (n=180)				Redistribution group (n=151)			
	n	expB(95%CI)	P		n	expB(95%CI)	P	
Intercept		1.0(0.2-5.5)	0.958			0.3(0.1-1.6)	0.164	
Age of respondent (years)	180	1.0(1.0-1.0)	0.690		151	1.0(1.0-1.0)	0.529	
Bo: middle-born(/first-born sons)	103/46	0.9(0.6-1.4)	0.817					
Bo: last-born(/first-born sons)	31/46	0.7(0.4-1.3)	0.257					
Bo: first-born (/middle-born sons)					48/79	1.0(0.6-1.6)	0.924	
Bo: last-born (/middle-born sons)					24/79	0.9(0.5-1.8)	0.814	
Number of male siblings	180	0.9(0.8-1.0)	0.191		151	1.0(0.9-1.1)	0.846	
Land size(ha)	180	1.0(0.7-1.3)	0.828		151	1.4(1.0-1.8)	0.027	*
Village 1(/2)	105/75	0.6(0.4-0.9)	0.018	*	88/63	0.5(0.3-0.8)	0.009	**
High school education (not educated/educated)	145/35	1.0(0.6-1.6)	0.935		133/18	0.3(0.2-0.7)	0.002	**
Christians/Muslims	143/37	1.1(0.6-1.9)	0.751		134/17	1.2(0.5-2.9)	0.625	
Land origin (not from family/from family)	19/161	0.6(0.3-1.3)	0.229		128/23	2.0(1.0-4.2)	0.050	*

Number of non-kin reciprocators in support network

	Inheritor group (n=180)				Redistribution group (n=151)			
	n	expB(95%CI)	P		n	expB(95%CI)	P	
Intercept		0.3(0.1-1.4)	0.131			4.2(1.3-113.8)	0.017	*
Age of respondent (years)	180	1.0(1.0-1.0)	0.426		151	1.0(1.0-1.0)	0.696	
Bo: middle-born(/first-born sons)	103/46	1.5(1.0-2.2)	0.037	*				
Bo: last-born(/first-born sons)	31/46	1.6(1.0-2.6)	0.045	*				
Bo: first-born (/middle-born sons)					48/79	1.1(0.8-1.6)	0.508	
Bo: last-born (/middle-born sons)					24/79	1.5(1.0-2.4)	0.055	.
Number of male siblings	180	1.0(0.9-1.1)	0.773		151	0.9(0.8-1.0)	0.050	*
Land size(ha)	180	1.1(0.8-1.4)	0.519		151	1.0(0.8-1.2)	0.752	
Village 1(/2)	105/75	0.6(0.4-0.9)	0.004	**	88/63	0.4(0.3-0.6)	0.000	**
High school education (not educated/educated)	145/35	1.0(0.6-1.5)	0.943		133/18	1.2(0.6-2.2)	0.613	
Christians/Muslims	143/37	1.7(1.0-2.9)	0.033	*	134/17	0.6(0.4-1.1)	0.123	
Land origin (not from family/from family)	19/161	1.0(0.6-1.6)	0.890		128/23	0.8(0.5-1.3)	0.444	

Notes: * p=0.05 **p=0.01

Figure 1

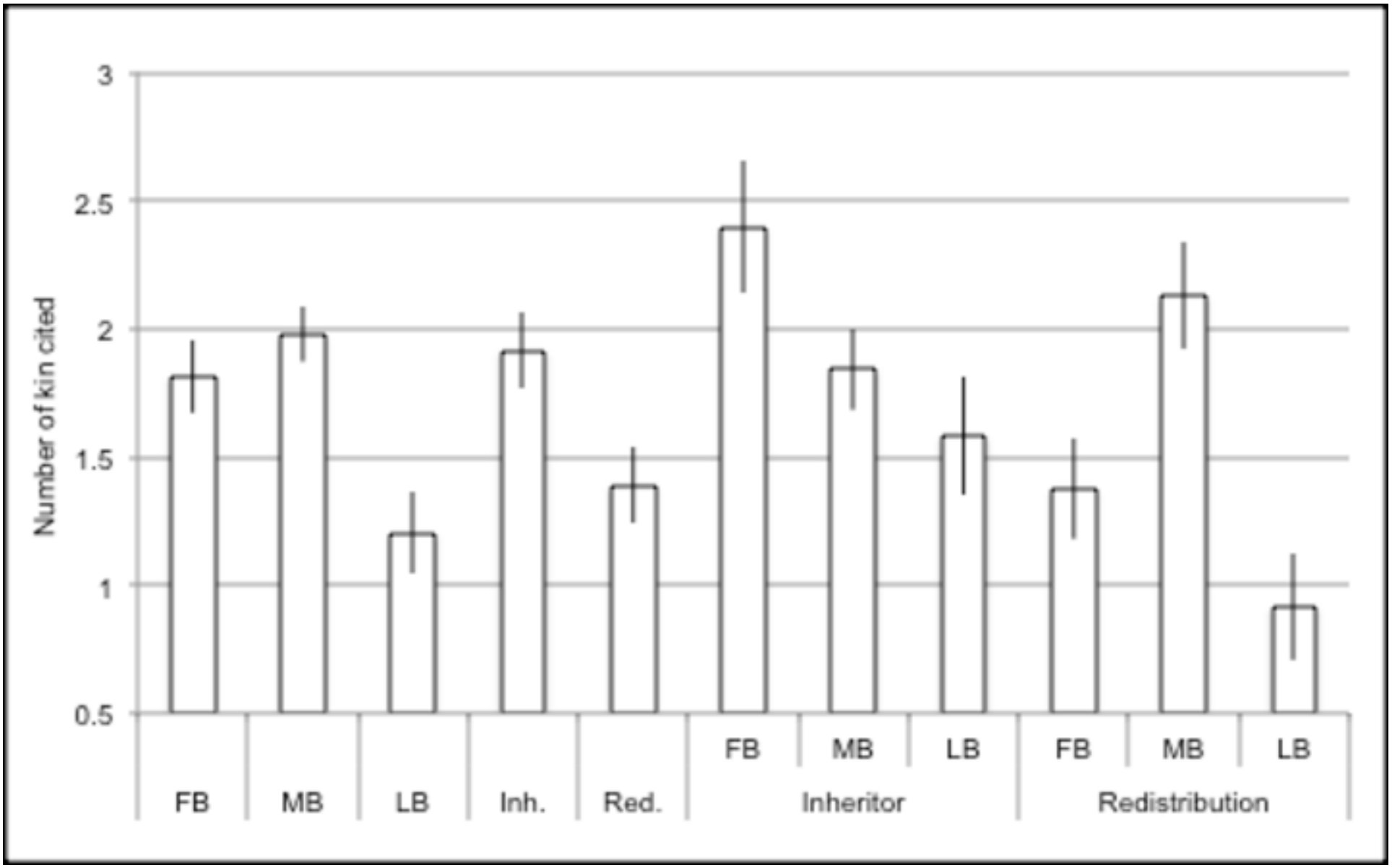


Figure 2a

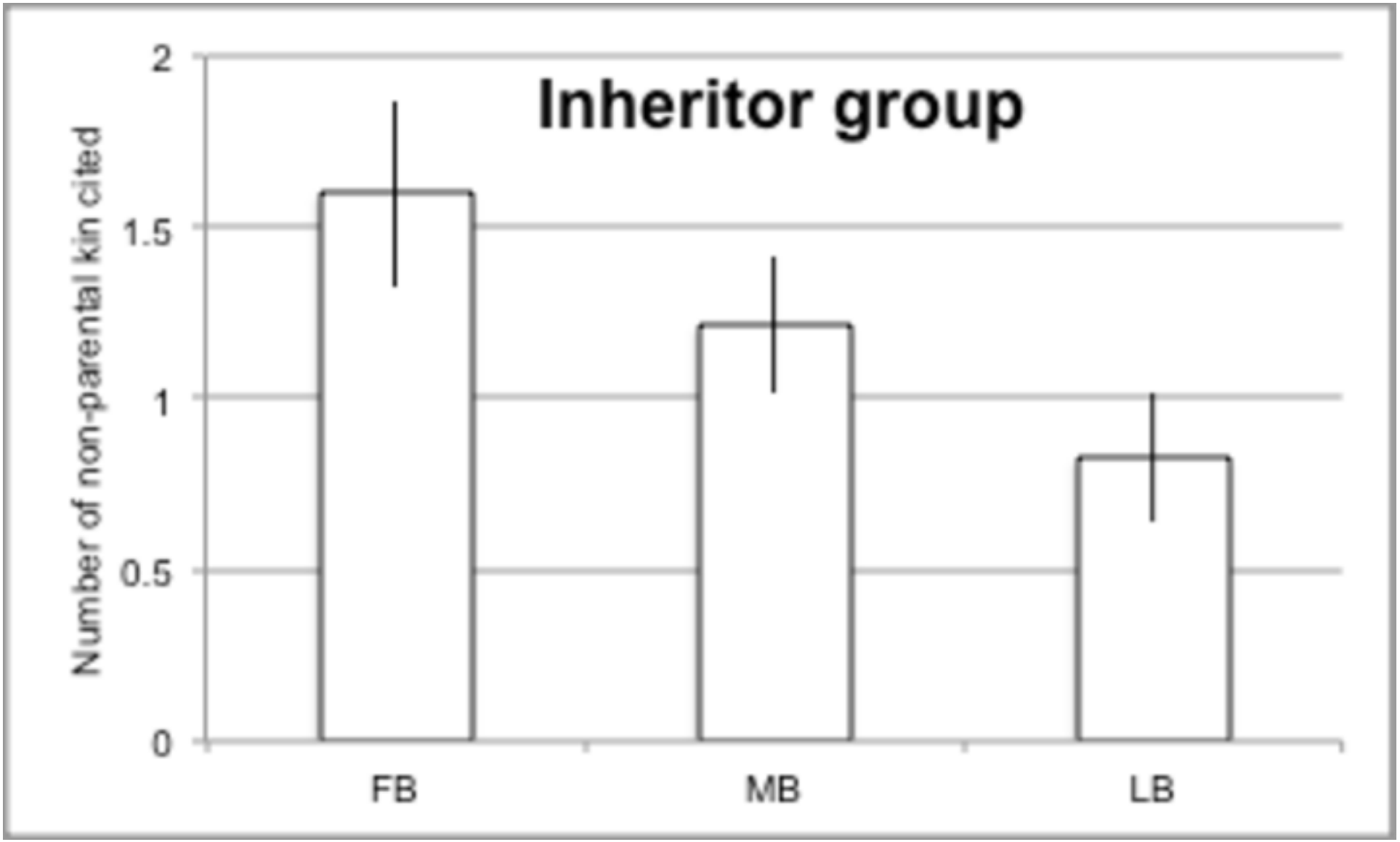
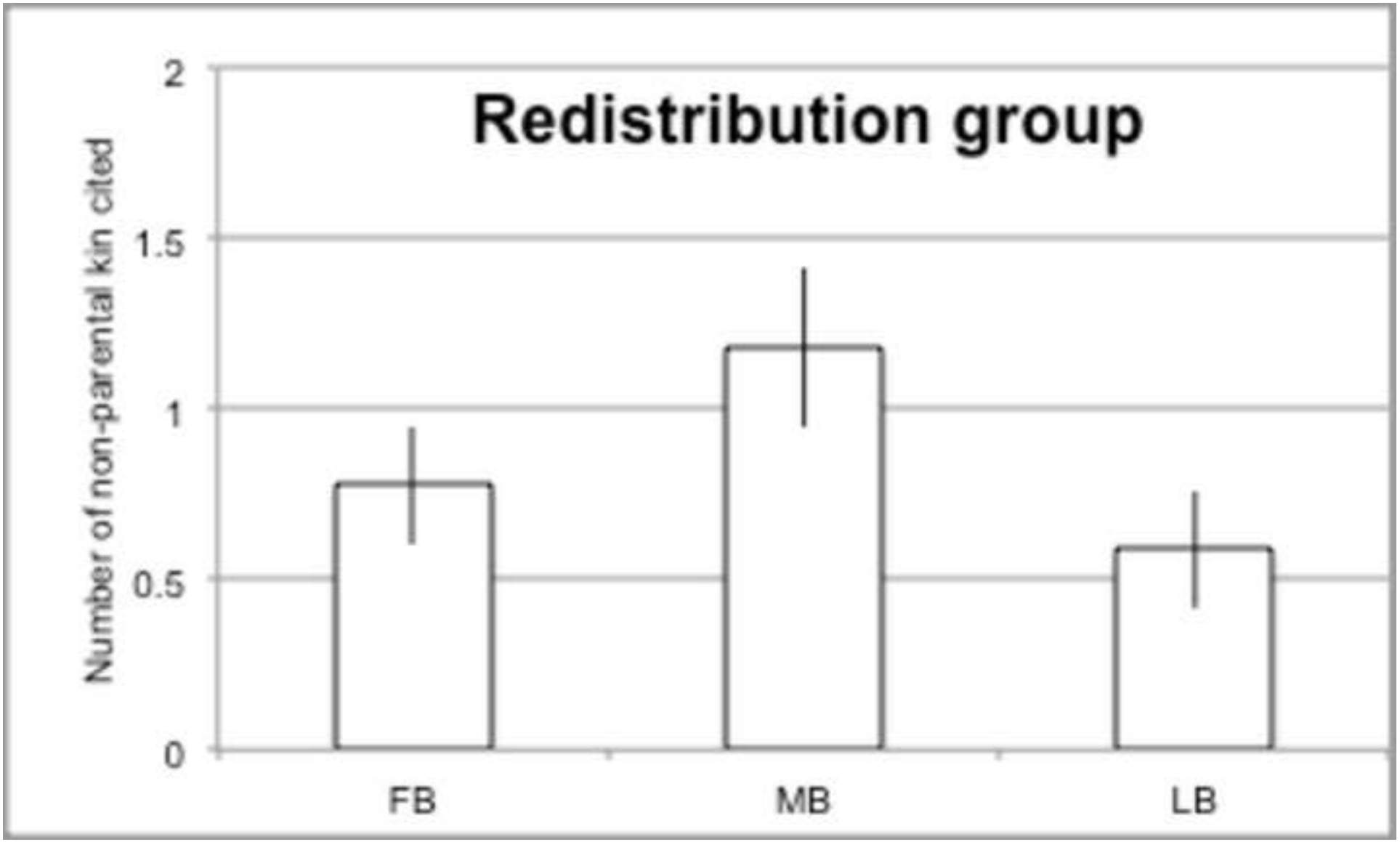


Figure 2b



Appendix- descriptive statistics

Does kin-selection theory help to explain support networks among farmers in South-Central Ethiopia?

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Sample	Variables	Mean	SD	Median	Min-max	N	Frequencies
Full sample	Full network size	3.34	1.38	3.00	0-7	331	
	Kin network size	1.82	1.51	2.00	0-7	331	
	Non-kin network size	1.52	1.46	1.00	0-6	331	
	Number of kin reciprocators	0.82	1.11	0.00	0-5	331	
	Number of non-kin reciprocators	1.02	1.35	0.00	0-5	331	
	Number of close-kin reciprocators	0.65	0.92	0.00	0-4	331	
	Number of distant-kin reciprocators	0.17	0.56	0.00	0-4	331	
	Number of non-reciprocal kin	1.01	1.41	0.00	0-6	331	
	Number of non-reciprocal non-kin	0.50	0.98	0.00	0-5	331	
	Number of non-reciprocal close-kin	0.81	1.22	0.00	0-6	331	
	Number of non-reciprocal distant-kin	0.20	0.51	0.00	0-4	331	
	Number of non-reciprocal kin helpers	0.41	0.75	0.00	0-3	331	
	Number of non-reciprocal non-kin helpers	0.27	0.63	0.00	0-3	331	
	Number of non-reciprocal close-kin helpers	0.30	0.63	0.00	0-3	331	
	Number of non-reciprocal distant-kin helpers	0.11	0.36	0.00	0-2	331	
	Age (years)	43.46	15.71	38.00	21-90	331	
	Land size (ha)	1.43	1.14	1.00	0.25-5	331	
	Sibling size	8.33	3.26	8.00	3-22	331	
	Male sibling size	5.00	1.97	4.00	3-15	331	
	BO categories					331	firstborns=65
						331	middleborns=233
						331	lastborns=33
	Male BO categories					331	first-born sons=94
						331	middle-born sons=182
						331	last-born sons=55
	Village					331	village 1=193
						331	village 2=138
	Generations					331	inheritors=151
						331	redistribution recipients=180
	Land origin					331	have received land from family=184
						331	have not received land from family=147
Inheritor group	Number of kin cited	1.99	1.53	2.00	0-6	180	
	Number of non-kin cited	1.94	1.39	1.00	0-6	180	
	Number of kin reciprocators	0.99	1.17	1.00	0-5	180	
	Number of non-kin reciprocators	1.02	1.32	0.00	0-5	180	
	Number of close-kin reciprocators	0.78	0.96	1.00	0-4	180	
	Number of distant-kin reciprocators	0.21	0.61	0.00	0-4	180	
	Number of non-reciprocal kin	1.00	1.40	0.00	0-6	180	
	Number of non-reciprocal non-kin	0.47	0.89	0.00	0-4	180	
	Number of non-reciprocal close-kin	0.77	1.15	0.00	0-5	180	

	Number of non-reciprocal distant-kin	0.23	0.58	0.00	0-4	180	
	Number of non-reciprocal kin helpers	0.40	0.74	0.00	0-3	180	
	Number of non-reciprocal non-kin helpers	0.26	0.60	0.00	0-3	180	
	Number of non-reciprocal close-kin helpers	0.28	0.58	0.00	0-3	180	
	Number of non-reciprocal distant-kin helpers	0.13	0.39	0.00	0-2	180	
	Number of non-parental kin network size	1.39	1.33	1.00	0-5	180	
	Number of non-parental kin reciprocators	0.71	1.04	0.00	0-5	180	
	Age (years)	31.48	4.42	32.00	21-40	180	
	Male sibling size	5.07	2.00	5.00	3-13	180	
	Land size (ha)	0.64	0.60	0.5	0.25-3.25	180	
	Cited a parent					180	yes=99
						180	no=81
	Reported a parent helper					180	yes=57
						180	no=123
	Reported helping a parent					180	yes=94
						180	no=86
	Reported a reciprocating parent					180	yes=49
						180	no=131
	Have at least one alive parent					180	yes=157
						180	no=23
	Male Bo categories					180	first-born sons=46
						180	middle-born sons=103
						180	last-born sons=31
	High school education					180	high-school educated=35
						180	did not complete high-school=145
	Village					180	village 1=105
						180	village 2=75
	Religion					180	Christians=143
						180	Muslims=37
	Land origin					180	have received land from family=161
						180	have not received land from family=19
Redistribution group	Number of kin cited	1.63	1.48	1.00	0-7	151	
	Number of non-kin cited	1.55	1.54	1.00	0-6	151	
	Number of kin reciprocators	0.61	1.00	0.00	0-4	151	
	Number of non-kin reciprocators	1.03	1.39	0.00	0-4	151	
	Number of close kin reciprocators	0.48	0.85	0.00	0-4	151	
	Number of distant kin reciprocators	0.13	0.48	0.00	0-3	151	
	Number of non-reciprocal kin	1.02	1.43	0.00	0-6	151	
	Number of non-reciprocal non-kin	0.53	1.08	0.00	0-5	151	
	Number of non-reciprocal close-kin	0.85	1.29	0.00	0-6	151	
	Number of non-reciprocal distant kin	0.17	0.41	0.00	0-2	151	

Number of non-reciprocal kin helpers	0.42	0.75	0.00	0-3	151	
Number of non-reciprocal non kin helpers	0.28	0.68	0.00	0-3	151	
Number of non-reciprocal close kin helpers	0.34	0.68	0.00	0-3	151	
Number of non-reciprocal distant kin helpers	0.9	0.32	0.00	0-2	151	
Number of non-parental kin network size	1.44	1.33	1.00	0-6	151	
Number of non-parental kin reciprocators	0.60	1.00	0.00	0-4	151	
Age (years)	57.75	11.90	55.00	41-90	151	
Male sibling size	4.91	1.97	4.00	3-15	151	
Land size (ha)	2.38	0.88	2.5	0.25-5.00	151	
Male Bo categories					151	first-born sons=48
						middle-born sons=79
						last-born sons=24
High-school education					151	high-school educated=18
						did not complete high school=133
Village					151	village 1=88
						village 2=63
Religion					151	Christians=134
						Muslims=17
Land origin					151	have received land from family=23
						have not received land from family=128
Have at least one alive parent					151	yes=54
					151	no=97

Response to the reviewers

Does kin-selection theory help to explain support networks among farmers in South-Central Ethiopia?

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Dear Dr Lancaster,

It is with great pleasure that we received your message.
The bio-sketches were updated and included in a separate file, the line numbers were removed from the manuscript, and separated files were created for the images.
Kind regards,
Lucie Clech

Dear Dr Clech,

Thank you very much for your careful revisions and response to the manuscript review.

You have ably met the editorial concerns and your manuscript entitled "Does kin-selection theory help to explain support networks among farmers in South-Central Ethiopia?" is ready for publication in Human Nature.

There are a few additional things I will need from you in order to ready the manuscript for copy-editing;

1.The revised manuscript in a clean format with no line numbers or embedded images. Please consult Springer.Science Instructions for Authors available on Human Nature's website, so that you can have everything in order.
2.A biographical sketch of each author.
3.The signed Disclosure of Interest Form, which is also available on Human Nature's website, mailed or emailed to me. The lead author can sign for both after first getting confirmation and clearly so indicating on the form.

In order to submit your corrected manuscript, please access the following web site:
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Congratulations, I look forward to publishing your manuscript.

Sincerely yours,
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